GENERAL LIBRARY,
UNIV. OF MICH.
30 MAR 1898

Compressed Air

DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. III. NEW YORK, MARCH, 1898. 99601 NO. 1

THE PASSAIC ROLLING MILL, PATERSON, N. J.
LOADING CARS WITH STRUCTURAL IRON BY AIR HOISTS.

LIDGERWOOD M'F'G CO.,

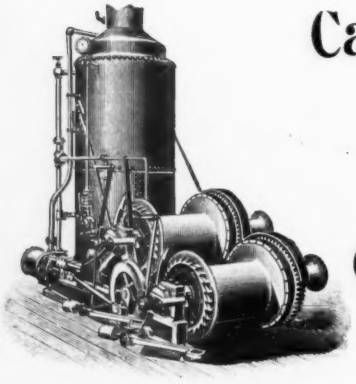
Boston.
Philadelphia.
Cleveland, O.

96 Liberty Street,
New York.

Chicago.
Portland, Ore.
New Orleans.

STANDARD
High . . .
Speed
Hoisting Engines,

Built on the Duplicate Part System.



Cableways,
Hoisting
and
Conveying
Devices,

For Canal and Trench Excavating, Dam Construction, Wall and Pier Building, Mining, Quarrying, Logging, and General Contract Work.

Fiske Brothers Refining Co.

NON-CARBONIZING OIL

FOR USE IN AIR CYLINDERS OF

AIR COMPRESSORS

Also All Grades of Lubricants for Use on Machinery

Propelled by Compressed Air

OFFICE AND SALESROOM, 59 WATER STREET,

CABLE ADDRESS,
"LUBROLEINE."

NEW YORK, U. S. A.

McNAB & HARLIN M'F'G CO.,

MANUFACTURERS OF

BRASS COCKS,

PLUMBERS' BRASS WORK,

Globe Valves, Gauge Cocks, Steam Whistles and Water Gauges,

WROUGHT IRON PIPE AND FITTINGS,

Plumbers' and Gas Fitters' Tools,

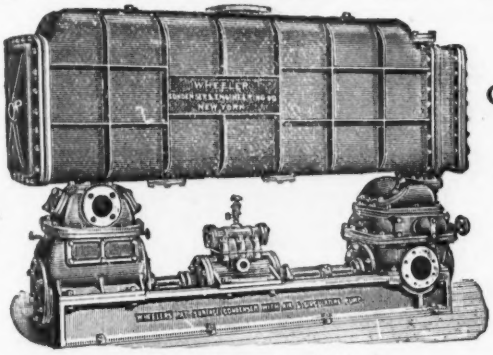
No. 56 JOHN STREET, - - NEW YORK.

Factory, Paterson, N. J.

Wheeler Condenser & Engineering Co.

120 & 122 LIBERTY STREET NEW YORK.

For MARINE and STATIONARY SERVICE.

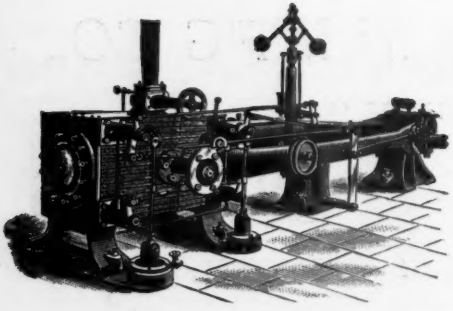


SURFACE CONDENSERS Mounted on Combined Air and Circulating Pumps.

PROPRIETORS AND MANUFACTURERS OF

WHEELER STANDARD SURFACE CONDENSER; WHEELER ADMIRALTY SURFACE CONDENSER; WHEELER LIGHTHALL SURFACE CONDENSER; VOLZ PATENT SURFACE CONDENSER AND FEED WATER HEATER; EDMISTON PATENT FEED WATER FILTER.

WHEELER'S PATENT FEED WATER HEATER.



Established
1833.

The
C. & G. COOPER CO.

MT. VERNON, OHIO.

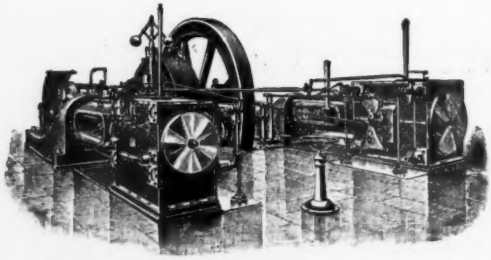
CORLISS ENGINES.

COMPOUND.

TRIPLE EXPANSION.

SINGLE CYLINDER.

Of all sizes up to 3,000 Horse-power.



— FOR —

FACTORIES, RAILWAYS, ELECTRIC LIGHTING, ROLLING MILLS, AND ALL KINDS OF MANUFACTURING.

CORRESPONDENCE SOLICITED.

HOME OFFICE: MT. VERNON, OHIO.

NEW YORK: Room 1022 Havemeyer Building, F. W. IREDELL, Mgr.

G. WILFRED PEARCE,
Electrical, Steam and Compressed Air Apparatus,
ST. PAUL BUILDING, NEW YORK.

Used by the Officers of all Railroads

(ISSUED QUARTERLY) THE POCKET LIST OF RAILROAD OFFICIALS
Subscription Price, $1.00 per annum. Advertising rates on application.

THE OFFICIAL RAILWAY EQUIPMENT REGISTER (ISSUED MONTHLY) Descriptive of freight and passenger cars of the Railways and Private Companies in the United States, Canada and Mexico.
Subscription Price, $5.00 per annum. Single copies, $1.00.
THE RAILWAY EQUIPMENT & PUBLICATION CO.
24 Park Place, New York.

Trimo Giant Pipe Wrench

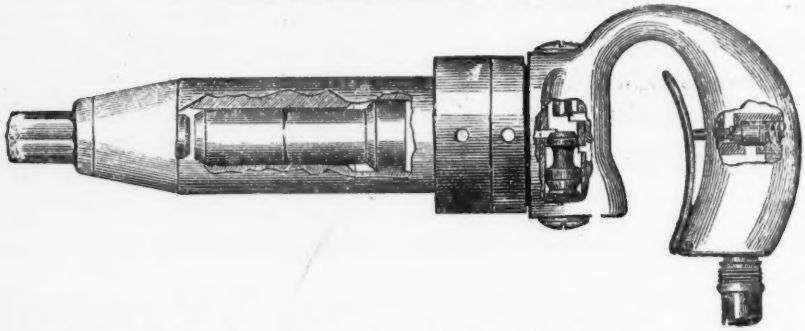
The strongest, safest and most durable Pipe Wrench in the world. Made and adapted for all kinds of work as well as hard or rough usage. Send for catalogue of Trimo tools.

TRIMONT MANUF'G CO., Roxbury, Mass.
FOR SE BY ALL JO BBERS.

No. 0.
PNEUMATIC
BREAST DRILL.
Weight, 10½ Lbs. Capacity to ½ In.
Simple, Durable, Efficient.
Empire Engine & Motor Co.,
26 CORTLANDT ST., NEW YORK.
MACHINES SENT ON TEN DAYS TRIAL.

United States Metallic Packing Co.,

PHILADELPHIA, PA.



Manufacturers of the most economical Air Tools in the market, such as

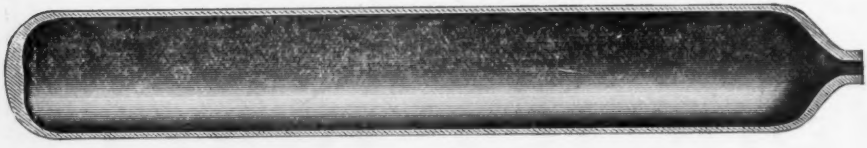
PNEUMATIC HAMMERS,
" DRILLS,
" TRACK SANDERS,
" BELL RINGERS.

METALLIC PACKING FOR ALL KINDS OF SERVICE.

CHICAGO OFFICE:
1003 MARQUETTE BUILDING.

OFFICE AND WORKS:
427 NORTH 13th STREET

MANNESMANN TUBE WORKS,



MANUFACTURERS OF

Seamless Rolled Tubes for Gases, Compressed Air, Etc.,

UNDER HIGH PRESSURE.

Tested and approved by the highest authorities and Governments of Europe and America.

Each Tube is carefully tested, and a Government Test Certificate is furnished with each Tube. Representatives:—

CHAS. G. ECKSTEIN & CO.,

45 VESEY STREET, - - - NEW YORK

J. D. MILLER & CO.,

TAYLOR BUILDING 39 & 41 CORTLANDT ST., N. Y.

COMPLETE POWER PLANTS,

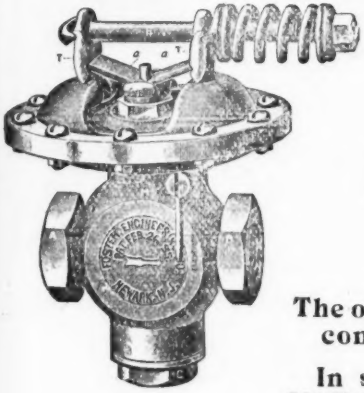
FOR ALL PURPOSES

ENGINES, BOILERS, MACHINERY,

MINING AND MILLING EQUIPMENTS.

Send for Catalogues and Estimates on what you need.

The FOSTER



New "Class W"
(Automatic)
Pressure
Regulator.

The only Pressure Regulator satisfactorily controlling High Initial Air Pressures.

In successful service on ALL the AIR-MOTORS yet tested.

FOSTER ENGINEERING CO.,

NEWARK, N. J.

PNEUMATIC APPLIANCES.

DRILLS, REAMERS, TAPPERS,
RIVETERS, CAULKERS, CHIPPERS,
HOISTS, MOTORS, COMPRESSORS,
STAY BOLT CUTTERS, SAND SIFTERS, ETC.

SEND FOR NEW CATALOGUE JUST ISSUED.

C. H. HAESELER CO.,

1026 - 1030 HAMILTON STREET, - - PHILADELPHIA, PA.

THE PELTON WATER WHEEL

Embracing in it variations of construction and application

THE PELTON SYSTEM OF POWER.

In simplicity of construction, absence of wearing parts, high efficiency and facility of adaptation to varying conditions of service, the **PELTON** meets more fully all requirements than any other wheel on the market. Propositions given for the development of water powers based upon direct application, or **Electric Transmission** under any head and any requirement as to capacity.

Compressed Air Transmission.

No other wheel is so well adapted to this purpose. Where the head admits, it can be attached to compressor shaft direct, and serve for prime mover and fly wheel as well.

Correspondence Invited. Catalogues Furnished upon Application. Address,

PELTON WATER WHEEL CO.,

121-123 MAIN STREET, SAN FRANCISCO, CAL.

143 LIBERTY STREET, NEW YORK.

BOSTON. NEW YORK. PITTSBURG. CHICAGO. ST. LOUIS.

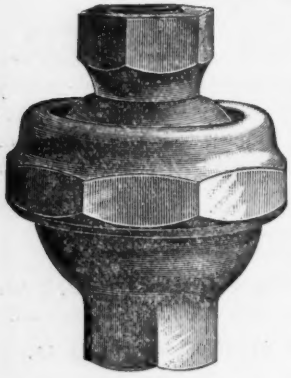
National Tube Works Company,

MANUFACTURERS OF

Standard Steam, Gas and Water Pipe.
Locomotive and Stationary Boiler Tubes.
Special Flanged Pipe for Compressed Air.
Pump Columns for Mines.
Special Light Lap-Welded Pipe, fitted with the Converse Patent Lock Joint for Water and Gas Mains.
Cylinders with Dished or Flat Heads for Carbonic Acid and other Gases.

NEW YORK OFFICE: HAVEMEYER BUILDING.

An Important Connecting Link in Compressed Air Service.



The Moran Flexible Joint

For high pressure, indispensible.

Tightness, safety, flexibility and durability assured.

Parties making experiments with Compressed Air may have the use of the "Moran Joint," free for a limited time.

MORAN FLEXIBLE STEAM JOINT CO.,

LOUISVILLE, - - - - - KENTUCKY.

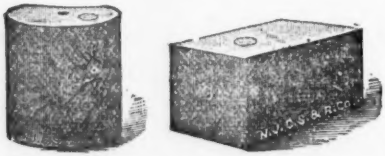
ESTABLISHED 1858.

"Our Name and Brand a Guarantee of Quality."

High Grade Rubber Goods.

CHANNELING SPRINGS.

BELTING.
TUBING.
VALVES.
HOSE
TUBING.



SPRINGS.
MATS.
MATTINGS.
GASKETS.
PLAY PIPES.

LINEN AND COTTON HOSE.

NEW JERSEY CAR SPRING & RUBBER COMPANY,

MAIN OFFICE AND WORKS:

Wayne and Brunswick Streets, Jersey City, N. J.

BRANCH OFFICE: 10 BARCLAY ST., NEW YORK.

Compressed Air.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Proprietor
A. E. KENNEY, - - Managing Editor
J. E. QUINTERO, - - - - - Treasurer

Subscription, including postage, United States, Canada and Mexico $1.00 a year. All other countries, $1.50 a year. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 26 Cortlandt St., New York.

London Office, 92 & 93 Fleet Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

VOL. III. MARCH, 1898. NO. 1.

Builders of air compressors and those who use compressed air will agree that the problem of heating or cooling air is a difficult one. Hot air in the cylinder of an air compressor means a reduction in the efficiency of the machine. The trouble is, that there is not sufficient time during the stroke to cool thoroughly by any available means. Water jacketing is the generally accepted practice, but it does not by any means effect thorough cooling. The air in the cylinder is so large in volume that but a fraction of its surface is brought in contact with the jacketed parts. Air is a bad conductor of heat and takes time to change its temperature. The piston while pushing the air towards the heat rapidly drives it away from the jacketed surfaces; so that little or no cooling takes place. This is especially true of large cylinders where the economy effected by water jackets is considerably less than for small cylinders. Engineers who are shown indicator cards from large air compressors with pressure lines running away from the adiabatic, naturally regard them with suspicion and look for leaks past the piston or through the valves. Such leaks will explain many isothermal cards, and until something better than a water jacket is devised, it is well to seek economy in air compression through compounding. The great advantage of compounding is in the fact that more time is taken to compress a certain volume of air and that this air while being compressed is brought in contact with a larger percentage of jacketed surfaces. The inter-cooler which should always be used with compound machines effects a larger saving by cooling and thereby causing the air to shrink in volume between the stages. The trouble with inter-coolers is that manufacturers are too prone to build them of cheap construction, economizing in machinery and in space and losing in thermic efficiency. A properly designed inter-cooler should reduce the temperature of the air back to the original point, that is to the temperature of the intake air. It can even do more than this, especially in winter when the water used in the inter-cooler is of low temperature. A simple coil of pipe submerged in water is not an effective inter-cooler, because the air passes through the coil too rapidly to be cooled to the core, and such inter-coolers do not sufficiently split up the air to enable it to be cooled rapidly. This splitting up of the air is an important point. It will not do to depend upon baffle plates, coils and other water jacketed features unless the air is split up while being brought in contact with them. A theoretically perfect inter-cooler is one in which the entire volume of air after partial compression is made to pass through wire cloth of close mesh, each wire being a tube through which water is passed, no such device is in use, as the mechanical difficulties probably stand in the way, but it is well for engineers in drawing up specifications for air compressors to pay close attention to the inter-cooler and in fact to all jacketed surfaces. A nest of tubes carrying water and arranged so that the air is forced between and around the tubes is an efficient form of inter-cooler. If the tubes are close enough together and are kept cold, the air must split up into thin sheets while passing through. Such devices are naturally expensive, but the first cost is a small expense when compared with the efficiency of the compressor, measured in the coal and water consumed.

Receiver inter-coolers are more efficient than those of the common type because the air is given more time to pass through the cooling stages and because of the freedom from wire drawing which may take place in inter-coolers of small volumetric capacity. This wire drawing is similar in effect to insufficient area of inlet and may be noticed by putting a pressure gauge on the inter-cooler.

After-coolers are in some installations as important as inter-coolers. An after-cooler

serves to reduce the temperature of the air after the final compression. In doing this it serves as a drier, reducing the temperature of the air to the dew point, thus abstracting moisture before the air is started on its journey. In cold weather with air pipes laid over the ground an after-cooler may prevent accumulation of frost in the interior walls of the pipes, for where the hot compressed air is allowed to cool gradually the walls of the pipe in cold weather act like a surface condenser and moisture may be deposited on the inside for the same reason that we have frost on the inner side of a window pane. Another advantage of the after-cooler is that it keeps the temperature of the line pipe uniform, otherwise this pipe will be hottest near the compressor, gradually cooling down and being thus subject to irregularities of expansion and contraction.

The Flow of Compressed Air in Pipes

[Continued.]

BY WILLIAM COX.

EXAMPLE 4.—It is required to discharge from a 6-inch pipe, 6400 feet long, the equivalent of 1166 cu. ft. of free air at a terminal pressure of 60 pounds. What must be the initial pressure?

Here $F = 1166$, $d = 6$, $c\sqrt{d^5} = 5273$, $l = 6400$, $p_2 = 60$, $w_2 = 5.08$.

Then, by Eq. (8) transposed

$$D = \frac{F}{w_2} = \frac{1166}{5.08}$$

$$= 229.5 \text{ cu. ft. at 60 lbs.}$$

By Eq. (11)

$$\sqrt{\frac{p_1 - p_2}{w_1}} = \frac{229.5 \times 80}{5273}$$

$$= 3.482.$$

Now running the eye along the line in Table VI. of 60 lbs. terminal pressure, we find under 5 lbs. loss the value of

$$\sqrt{\frac{p_1 - p_2}{w_1}} = 3.479$$

This is therefore the resulting friction pressure, whence the initial pressure must be $60 + 5 = 65$ lbs.

EXAMPLE 5.—Take the same case as Example 4, but limit the loss of pressure to 2 lbs. How much air will be discharged at 60 lbs. final pressure?

From Table VI. under 2 lbs. loss, and opposite 60 lbs. final pressure, we find

$$\sqrt{\frac{p_1 - p_2}{w_1}} = 2.242$$

Inserting this in Eq. (5) we obtain

$$D = \frac{5273}{80} \times 2.242$$

$$= 147.76 \text{ cubic feet air at 60 lbs. final pressure.}$$

Supposing now that this quantity does not suffice, what diameter of pipe will be required to discharge the 229.5 cu. ft. air at 60 lbs. with a loss of 2 lbs. only, making the initial pressure = 62 lbs?

By Eq. (10)

$$c\sqrt{d^5} = \frac{229.5 \times 80}{2.242}$$

$$= 8185.$$

From Table II. the diameter of the pipe would have to be about 7¼ inches.

EXAMPLE 6.—It is desired to discharge from a 4-inch pipe 150 cu. ft. air at a final or exit pressure of 60 lbs. How long can the pipe be so that the loss of pressure shall not exceed 5 lbs.?

Here $D = 150$, $d = 4$, $c\sqrt{d^5} = 1856$, $p_1 = 65$, $p_2 = 60$.

Transposing Eq. (9) and by Table VI., we have

$$l = \left(\frac{c\sqrt{d^5}}{D} \times \sqrt{\frac{p_1 - p_2}{w_1}}\right)^2 \quad \ldots\ldots (12)$$

$$= \left(\frac{1856}{150} \times 3.479\right)^2$$

$$= 1853 \text{ feet long.}$$

EXAMPLE 7. — Supposing that in Example 6, the initial pressure remains at 65 lbs., and that the pipe is 3706 feet (or twice as long); what will be the final pressure, the volume of discharge being still 150 cu. ft. of compressed air?

Here $D = 150$, $d = 4$, $c\sqrt{d^5} = 1856$, $p^1 = 65$, $l = 3706$, $\sqrt{l} = 60.877$.

Required to find p_2.

By Eq. (11).

$$\sqrt{\frac{p_1 - p_2}{w_1}} = \frac{150 \times 60.877}{1856}$$

$$= 4.92.$$

Now by Table VI. we see that 4.92 is the value of $\sqrt{\frac{p_1 - p_2}{w_1}}$ for a final pressure of 55 lbs. with 10 lbs. loss, making the initial pressure 65 lbs. as required.

It will be noticed that in Example 7 the length of the pipe and the loss of pres-

sure are each *twice* as much as in Example 6, the discharge in each case being 150 cu. ft. of compressed air. BUT :—*and this is the great point to be noted*—we have in the former case 150 cu. ft. of air discharged at 60 lbs. final pressure, the equivalent volume of free air being 762 cu. ft., whereas in the latter case we have 150 cu. ft. of air discharged at 55 lbs. final pressure, whose equivalent volume of free air is only 711 cu. ft., or 51 cu. ft. less, being equal to a diminished discharge of 6.7 per cent. Hence, *when the initial pressure and the volume of compressed air discharged from a pipe remain constant, the loss of pressure will be proportionate to the length of the pipe.*

For further exemplification of this most important truth, which has been so often misstated, see Table 10 following, and also deductions therefrom.

A formula is like a theorem in logic. If no important truths can be deduced from it, it is of doubtful value. It may therefore in the present case be useful to see what this formula teaches regarding the flow of compressed air in pipes. It will also certainly be interesting to know from those who have had practical experience in the matter, if these deductions have had their fulfilment in the case of existing installations.

It seems to the writer that the best method of examining the formula with this object in view will be by means of short tables, designed to show the changes wrought in certain of its factors by slightly varying conditions of the other factors, and then deducing from each table the truths thus exposed to view.

In Tables 7, 8 and 9 following, it is assumed that we are dealing with a 6-inch pipe, 10,000 feet long, thus giving the value of

$$\frac{c\sqrt{d^5}}{\sqrt{l}} = \frac{5273}{100} = 52.73$$

TABLE VII.

Take $p_1 = 60$ lbs. gauge, constant, and $p_1 - p_2$ as increasingly variable.

p_1	$p_1 - p_2$	$\sqrt{\frac{p_1 - p_2}{w_1}}$	p_2	Discharge Comp. Air.	w_2	Equivalent Free Air.
lbs.	lbs.		lbs.			
60	1	1.608	59	84.8	5.012	425.0
60	2	2.273	58	119.8	4.944	592.3
60	3	2.785	57	146.8	4.876	715.8
60	4	3.216	56	169.6	4.808	815.4
60	5	3.596	55	189.6	4.740	898.7

It will be noted here that the initial pressure remains constant at 60 lbs., so that the density of the entering air will be likewise constant. The discharge of compressed air will be seen to increase with each increase of loss of pressure, but in a decreasing ratio, that is, *as the square root of the loss of pressure*. Thus, with a loss of 4 lbs. the discharge is only twice as great as with a loss of one pound. It will also be seen that the discharge of equivalent free air increases with the increasing loss of pressure, but in a still greater decreasing ratio than that of the compressed air discharge, seeing that the ordinary values of w_2 are used (See Eq 8) and not their square roots.

It is also evident that although the initial pressure is maintained at 60 lbs., and the loss of pressure increases from one to five pounds, *the cost of running the compressor with the higher loss will be greater*, as the increased loss must be counterbalanced by the intake of a greater volume of equivalent free air, in order that the initial pressure may be maintained at 60 lbs. This condition also applies more or less to Tables VIII. and IX.

TABLE VIII.

Take $p_1-p_2=5$ lbs. gauge, constant, and p_1 and p_2 as uniformly variable.

p_1	p_1-p_2	$\sqrt{\frac{p_1-p_2}{w_1}}$	p_2	Discharge Comp. Air.	w_2	Equivalent Free Air.
lbs.	lbs.		lbs.			
65	5	3.479	60	183.4	5.080	931.7
66	5	3.458	61	182.3	5.148	938.5
67	5	3.437	62	181.2	5.216	945.1
68	5	3.417	63	180.2	5.284	952.2
69	5	3.397	64	179.1	5.352	958.5
70	5	3.376	65	178.0	5.420	964.8

This table shows that although the initial and final pressures correspondingly increase, the loss of pressure remaining constant, the volume of compressed air discharged decreases in a uniformly decreasing ratio, that is, inversely as the square root of the density of the air at its initial pressure. On the other hand the volume of equivalent free air entering and being discharged from the pipe increases continually bnt in a decreasing ratio.

TABLE IX.

Take $p_2=60$ lbs. gauge, constant, and p_1 and p_1-p_2 as corresponding variable.

p_1	p_1-p_2	$\sqrt{\frac{p_1-p_2}{w_1}}$	p_2	Discharge Comp. Air.	w_2	Equivalent Free Air.
lbs.	lbs.		lbs.			
61	1	1.597	60	84.2	5.08	424.5
62	2	2.242	60	118.2	5.08	600.4
63	3	2.730	60	143.9	5.08	731.0
64	4	3.132	60	165.1	5.08	838.7
65	5	3.479	60	183.4	5.08	931.7

In this table the initial pressure and the loss of pressure increase uniformly, while the final pressure remains constant. It will be seen that the volume of compressed air discharged increases with the increase of the initial pressure and the loss of pressure but in a decreasing ratio, that is, as the square root of the loss of pressure divided by the square root of the initial density. The discharge of equivalent free air increases exactly in the same ratio as the discharge of compressed air, seeing that the value of w_2 is constant throughout, being dependent upon the final pressure p_2, which is also constant.

TABLE X.

Take a 4-inch pipe 1853 to 3706 feet long, whence $c\sqrt{d^5}=1856$. Assume $p_1=65$ lbs. gauge, constant, and $D=150$ cubic feet constant.

p_1	Discharge Comp. Air.	l	$\sqrt{\frac{p_1-p_2}{w_1}}$	p_1-p_2	p_2	w_2	Equivalent Free Air.
lbs.				lbs.	lbs.		
65	150	1853	3.479	5	60	5.080	762
65	150	2224	3.811	6	59	5.012	752
65	150	2594	4.117	7	58	4.944	742
65	150	2965	4.400	8	57	4.876	731
65	150	3335	4.668	9	56	4.808	721
65	150	3706	4.920	10	55	4.740	711

Here the discharge of compressed air is constant throughout, and the loss of pressure is exactly proportionate to the length of the pipe. As the final pressure, and consequently w_2, diminish with the length of the pipe, the volume of equivalent free air discharged must diminish in the same ratio as w_2, as also obviously the equivalent volume of free air entering the pipe. If on the other hand the volume of equivalent free air entering the pipe at a uniform initial pressure were constant, it is clear that the loss of pressure would be greater proportionatly than the increase in the length of the pipe.

TABLE XI.

p_1	Comp. Air entering the Pipe.	Equivalent Free Air.	l	$p_1 - p_2$	p_2	Discharge Comp. Air.
lbs.	c. ft.	c. ft.	feet.	lbs.	lbs.	c. ft.
65	140	762	1853	5	60	150
65	140	762	2162	6	59	152.1
65	140	762	2460	7	58	154.2
65	140	762	2730	8	57	156.3
65	140	762	2988	9	56	158.5
65	140	762	3226	10	55	160.7

In this table the initial pressure and the volume of compressed and equivalent free air entering the pipe are all constant, but the loss of pressure and the length of pipe increase, although not correspondingly. Thus, for increasing losses of one pound, the length of pipe increase as follows :

	Length of pipe.	Prop'te length.	Difference.
Loss of 5 lbs.	1853 ft.	1853 ft.	....
" 6 "	2162 "	2224 "	62 ft.
" 7 "	2460 "	2594 "	134 "
" 8 "	2730 "	2965 "	235 "
" 9 "	2988 "	3335 "	347 "
" 10 "	3226 "	3706 "	480 "

whence it is clear that when referring to the flow of free air (equivalent) in pipes, the loss of pressure *is not proportionate to the length of the pipe*, the volume of air entering the pipe being constant, as also the initial pressure.

TABLE XII.

Particulars of pipe, pressure, discharge, etc., the same as for Table VII. Area of pipe = 28.27 square inches, which gives for a 6 inch pipe, $v = \frac{D}{11.78}$

p_1	Comp. Air Entering.	Velocity.	p_2	Comp. Air Discharged.	Velocity.	Equivalent Free Air.	Velocity.
lbs.			lbs.				
60	83.66	7.10	59	84.8	7.20	425.0	36.08
60	116.60	9.90	58	119 8	10.17	592.3	50.28
60	140.90	11.96	57	146.8	12.46	715.8	60.76
60	160.50	13 62	56	169.6	14.40	815.4	69.22
60	176.90	15 01	55	189.6	16.09	898.7	76.29

From the above it may be noticed that two different velocities have to be taken into account. Of these, the velocity of equivalent free air is constant throughout the length of the pipe when the initial pressure and the loss of pressure are maintained at the same point. On the other hand the velocity of the compressed air is continually varying, being the lowest at entry, and increasing by degrees as it flows along to the point of discharge The formula clearly explains the reason of this, seeing that it shows,

1st. As the compressed air flows through the pipe, friction takes place, producing an increasing loss of pressure as the compressed air advances.

2nd. By reason of this loss of pressure, the pressure to which the air is compressed decreases as it flows along.

3rd. Diminished pressure involves diminished density of the compressed air, hence,

4th. The original volume of compressed air entering the pipe becomes continually greater, and as the entry pressure remains constant, this greater volume must pass any given point in the pipe in the same time as the original smaller volume, whence

5th. To accomplish this, the rate of speed or velocity of flow must constantly increase to the end of the pipe.

Other interesting deductions from this formula could have been made, and will suggest themselves. What has been set forth in these articles will, it seems to the writer, show that the formula is applicable to the flow of elastic fluids, such as air and steam, in pipes; that it is logical, and that with the help of Table VI. it enables the solution of any practical problem to be quickly and very easily obtained.

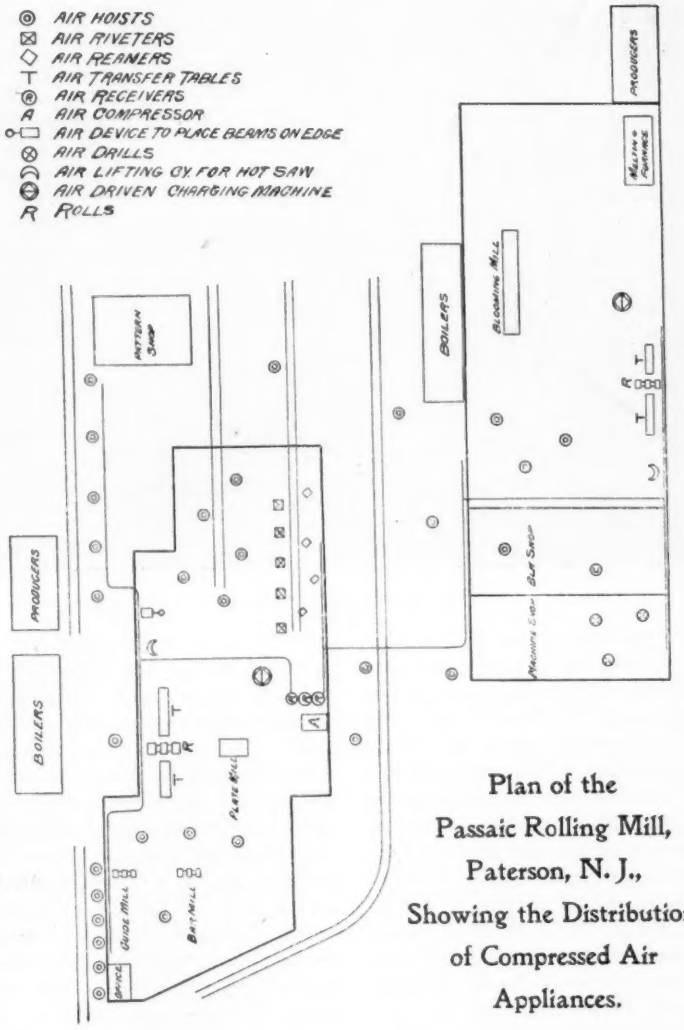
Further experience may of course go to show that D'Arcy's coefficients require somewhat modifying, but it should be remembered that no two series of experiments can be expected to be undertaken under precisely similar conditions, so that slightly varying results must be looked for, but they will not for this reason affect the reliability of the formula.

Compressed Air in a Rolling Mill.

Most of the more successful iron-working establishments now use "air"—a little—some a great deal, and among the foremost of the latter class is the Passaic Rolling Mill Co. at Paterson, N. J,, not only because of their extensive use of compressed air, but particularly by reason of the variety of operations performed by it, several of which are of more than ordinary interest and we believe originality. These works cover about 25 acres of ground, employ about 1200 men, and have a monthly output of about 5,000 tons, chiefly structural steel, a considerable portion of which is manufactured into bridge trusses, columns, &c., at the works, so it will be seen that compressed air has there a good field in which to demonstrate its value.

The view on the outside front cover of this magazine shows partially the row of jib cranes, each equipped with independent air hoist, used for loading the finished materal on cars for shipment. The air cylinders for this work are about 6 in. diamater by 6 ft. stroke, mounted on the mast. the air connection being made with a short piece of hose at the top of the crane.

Figure 1 illustrates one of the most interesting applications of compressed air; one in which work formerly requiring the services of thirteen men is now done by four, and with less danger. By it the capacity of the rolls has been trebled. This apparatus is not operated entirely by compressed air, steam and air being assigned to the work for which each was considered best suited. It consists of two transfer tables, one on each side of the main rolls of the rolling mill, the duty of one of which is to deliver the heated



Plan of the Passaic Rolling Mill, Paterson, N. J., Showing the Distribution of Compressed Air Appliances.

FIG. 4.

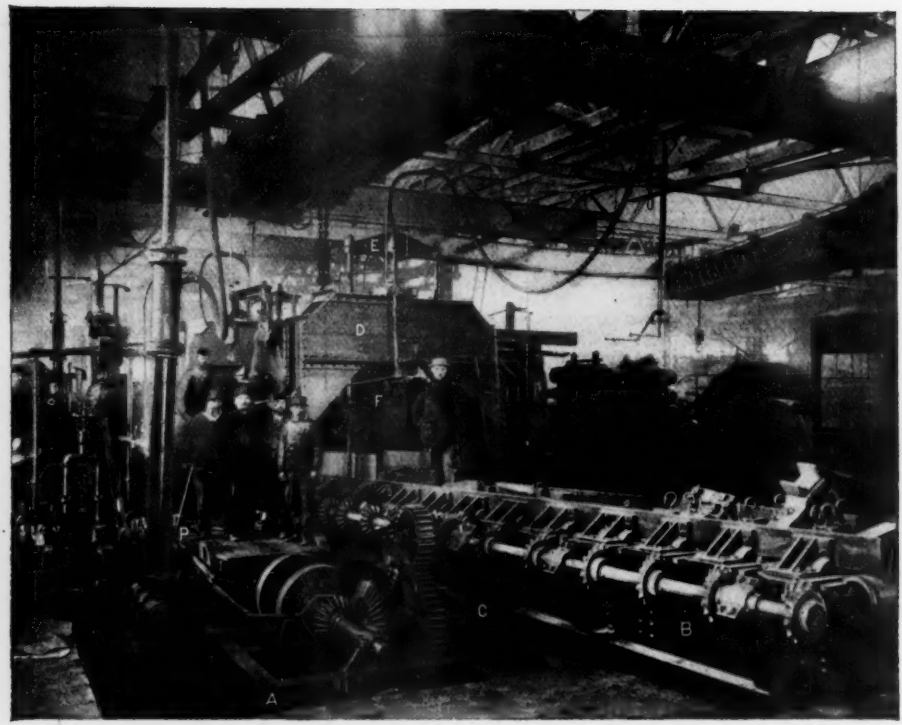


FIG 1.—TRANSFER TABLE.

billet to the first roll, move into position to receive it from the second, move and deliver it to the third, and so on till the billet comes out a finished beam. Of course the process described applies to the table on one side of the rolls only, the one on the opposite side operating in the same way with it This transfer table consists of a heavy four-wheeled carriage A carrying a tilting platform or girder B (with fulcrum at C), the top of which consists of rollers operated in either direction by the level gears and shaft plainly shown in the cut. The carriage travels in the pit on rails parallel to the rolls in moving from one roll to the next, and the end of the tilting table next the rolls is raised and lowered to position for the upper and lower rolls by an 18 in. air cylinder located in the yoke D. The crossbend E is connected at its center to the piston of this air cylinder and moves the tilting platform by means of the side rods fastened to its ends. The action of this cylinder is controlled by a special valve F, operated from the engineer's platform at P. The men shown in the cut were engaged in changing rolls at the time the photo was taken and are in no way connected with the operation of the table, one engineer and a roll tender being all that is required for the apparatus shown in the cut, and the same number for the other table (not shown) on the opposite side.

After the beam leaves the rolls it passes to the hot saw shown in Fig. 2, where it is trimmed and cut to length The rollers A, Fig. 2, receive it from the rollers on the

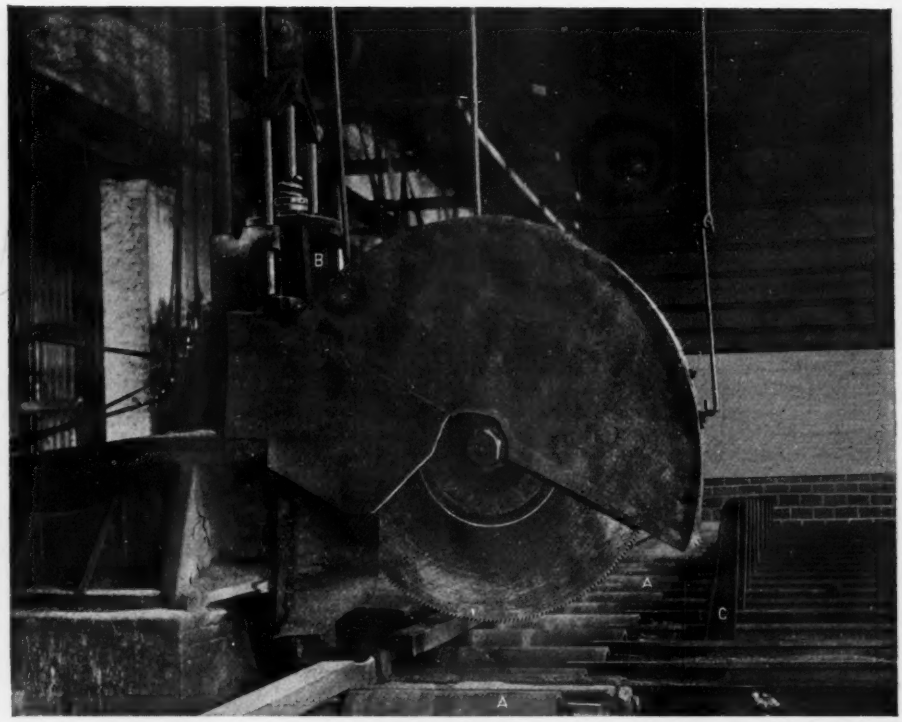


FIG 2.—AIR CYLINDER FOR LIFTING HOT SAW AND DEVICE FOR PLACING BEAMS ON EDGE. OPERATED BY AIR.

table, Fig. 1, without any handling or even a pause in its motion, so that a few seconds after it has received its last squeeze in the rolls it is being cut by the saw. This saw is fed through the beam by the compressed air cylinder B, which is 12 in. diameter by 20 in. stroke; the elastic yet persistent nature of the feed given the saw by compressed air is found much better than any other method.

Compressed air performs the next operation on the beam, which is to remove it from the rollers (making room for the next) and set it on edge to cool. When the beam lays on the rollers after being cut to length the fingers (C) are in a horizontal position under it between the rollers, and an air cylinder, 15x36 in., located under the rollers pulls the fingers to a vertical position, bringing the beam with it, at the same time carrying it sideways far enough to clear the rollers.

The rest of the work done by air in these works is being done in many places elsewhere, and is consequently of but passing interest. Fig. 3 shows a busy corner in the bridge shop—a group of three riveters, two reamers, a chipping tool and hoist, all being operated by compressed air. The total pneumatic equipment of the works, outside of the special apparatus described consists of about 40 cylinder hoists, 12 riveters, 5 drills and reamers, and 2 chipping tools, They now have nearly completed a very interesting device for charging the heating furnace, which we hope

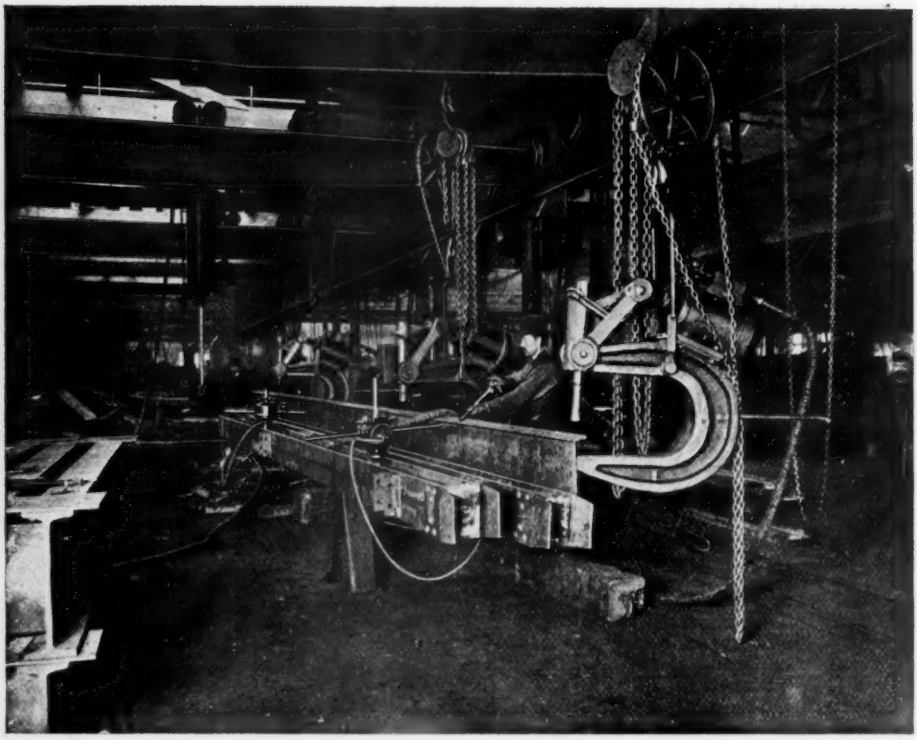


FIG. 3.—AIR HOIST, AIR DRILLS, AIR HAMMER AND AIR RIVETERS

to describe in a future article. This equipment is being constantly increased, especially the number of hoists, which vary from 4 in. to 12 in. diameter and up to 6 or 8 foot lift, used for handling material throughout the works.

Fig. 4 is a ground plan showing the approximate location of these compressed air appliances.—(See page 392).

Great credit is due their master mechanic, Mr. J. E. Jones, to whose energy and inventive ability is largely due the successful installation of this aggregation of pneumatic appliances, the value of which it is difficult to even estimate, and the cost of which was comparatively very low. The officers of the company (all of whom are great advocates of the use of compressed air) are: Mr. Watts Cooke, President; Mr. W. O. Fayerweather, V. P. and Treasurer; Mr. A. C. Fairchild, Secretary; Mr. John K. Cooke, Superintendent, and Mr. G. H. Blakeley, Chief Engineer.

Ample compressed air for this plant is furnished by one Class A Straight Line Piston Inlet Ingersoll-Sergeant Air Compressor, which is controlled by an automatic device, so that steam is used only in proportion to air used in the works, which naturally varies within wide limits. Fig. 5 is a view of this style of compressor, which the owners state is very satisfactory.

These works seem to be more favorably situated than would at first thought appear; they have in their yards the tracks of the Delaware, Lackawanna & Western and Erie Railroads and are very convenient to the New York Market.

HARRY M. PERRY.

* Hydraulic Plant for Compressing Air.

The term "hydraulic plant for compressing air" may, of course, include all machinery for compressing air in which water takes any part. It should, however, certainly be restricted to the cases where water is the main agent—*i.e.*,, to cases of the application of water power to the compression of air, and that is the sense in which the term is here used. The most usual way of applying water power to this purpose is to cause the water to produce rotary motion in some sort of a wheel, and by means of this rotary motion to drive reciprocating pumps in which air is received and compressed. This is obviously rather a roundabout process, involving the use of two distinct machines besides gear connecting them, and several conversions of energy. It is, of course, well known that though energy is indestructible it cannot be changed from one form to another without loss, and consequently, if there are several transformations of energy, there must be several losses. In converting the potential energy of water descending from a height into the rotary energy of a turbine, from 20 to 25 per cent. is usually lost. In the gear required to connect the wheel to the pumps there is also lost a percentage of the energy of the wheel, and in converting this energy to that of the reciprocating pistons, a third loss is suffered. The loss due to intermediate gear is frequently very considerable, because a turbine necessarily runs at a high speed and the pumps must run at a low speed. The consequence is that the net energy received by the pump piston is seldom more than half that of the original energy of the water, and is often much less. If, therefore the power of the water could be applied more directly, we should expect to attain a great economy of power; consequently, many efforts have been made to secure this object. Obviously, these considerations apply to the use of water power for any kind of pumping—*e.g.*, pumping water, as well as compressing (*i.e.*, pumping air)—but in the case of air-compression there is still another reason for desiring the direct application of the power. All the work done in compressing air is converted into heat, but when air is compressed under such conditions that all the heat is instantly and entirely absorbed by surrounding solid or liquid bodies, only about half as much net work is exerted (if, for example, compression is to one-fifth of original volume) as when no heat is thus absorbed. Therefore, it is obvious that it is of the highest importance to thus absorb heat during compression of air. In compressing air in reciprocating pumps, it is found practically impossible to absorb more than half the heat which is developed, and this is not surprising when we find that the greatest quantity of water which can practically be used, under the circumstances, for cooling is about two-thirds the weight of the air compressed, while the quantity of heat to be removed is very large indeed, amounting to fifty-eight heat units per pound of air when compressed to five atmospheres. But the quantity of water actually available when the motive power is water is never less than 1,000 times the weight of the air. Hence the strongest reason for applying the water used for power directly to the air—that if it can be done it should result in very much more thorough absorption of heat than can be accomplished in any other way. This analysis of the imperfection of air-compressing machinery is, of course, modern, but the practical result—that the inefficiency was very great—has been realized in a rough way ever since compressed air has been in common use, and, therefore, the attempts to apply the water directly have been many.

In this paper the author intends to confine his attention to those hydraulic air compressors which more or less perfectly attain this object. They may be divided into two classes:—In that which will be mentioned first the compression is effected by the weight of a column of water of a height equal to the maximum pressure of the air measured in feet of water. To obtain this pressure the water used as power is carried down a well or shaft and up again in an inverted siphon. The air to be compressed is diffused through the water in bubbles as small as possible, and part of it is then carried down to the bottom of the well by the stream. That which arrives there is, of course, then subject to the pressure of the water column above it and is accordingly compressed, and means are provided for allowing it then to escape from the water before it can again expand. This method is one of the very oldest known. One form of it is described by Pliny in the first century, and even then was old. In modern times several diff rent inventors have revived it, and it is connected with the names of Upham, Mowbray, Frizell and C. H. Taylor. In this

* Paper read by Mr. H. D. Pearsall, M. Inst. C. E. of London, before Manchester Ass'n of Engineers.

machine, as might be expected, the compression is isothermal, and it is a very simple machine and has few working parts. It is, however, rather an expensive one, as for a pressure of five atmospheres it requires the sinking of a shaft 150 ft. or more in depth, with an enlarged chamber and some of the apparatus at the bottom of the shaft. Moreover, when its principles are examined, it is found that the unavoidable losses connected with it are large, so that its theoretic efficiency is not very high. These may be chiefly embraced under the head of fluid friction due to the flow through a pipe 300 feet long and to eddies. The fluid friction is not merely that of water flowing through a pipe. The bubbles of air, although they descend with the water do not descend as fast as the water. Consequently the water is all the time passing the bubbles, and the rubbing surface causing fluid friction is, therefore, the whole surface of innumerable bubbles of air, in addition to the surfaces of the pipe. The co-efficient of friction is, therefore, very much greater than that of water in a pipe. The efficiency actually realized in practice appears to have been about 55 per cent. under the condition of using a very large pipe, a low fall and a pressure of only four atmospheres. Both a higher fall and a higher pressure diminish the possible efficiency.

In the other class of machines having the same object water acts as a piston, compressing the air in a chamber provided for the purpose. The earliest is probably due to Montgolfier, the inventor of gas balloons and of the hydraulic ram, about one hundred years ago, who described and patented a modification of his hydraulic ram to be used for the compression of air. It was quite a practicable machine, though possessing some complications which have been proved to be needless But the reason why it has failed to come into use is the same reason which for so many years has confined the hydraulic ram for water raising to machinery of small and almost domestic size, viz., the construction of the main valve. In Montgolfier's machine the escape valve was similar to that of the Montgolfier water ram, and it was operated as that is, by the current of the escaping water. This necessarily limits these machines to a very small size, and, as when compressed air is wanted, it is nearly always wanted in considerable quantity, this alone would naturally prevent any use being found for these machines. That this construction was unsuitable for any large size one supposes should have been obvious; but, as for one hundred years, in nearly all attempts to improve the ram they insisted on retaining it, it seems it was not obvious. It was, however, abandoned in the next application of this principle which will be mentioned. This is the air compressor designed and used by Sommeiller in the excavation of the Mount Cenis tunnel. It consists of a pipe leading from the source of supply, two valves, a vertical pipe in which air is compressed, and a valve controlling the connection between this compression chamber and an air-vessel. The water does not act merely by its pressure. When it begins to flow, the air in the pipe offers very little opposition to it, and therefore the water acquires a high velocity and momentum. As the air becomes compressed it offers more and more resistance to the water, and this resistance absorbs the momentum of the column of the water. The compression is effected, therefore, more by the momentum of the column of water, than by its pressure. Hence it is essentially an hydraulic ram. The head of water was 85 ft., and the air was compressed to 6 atmospheres. Notwitstanding numerous defects of designs, these machines had considerable success. Ten of them were made, and after they had been in use three years at the Bardonneche end of the tunnel, six others were made for the Modane end of the tunnel, where the fall was only 35 feet. In this latter installation a most remarkable course was adopted, the history of which is very instructive. The natural fall being only 35 feet, the water was first pumped by water-wheels to a reservoir at a height of 85 feet, and then used with this fall in the compressors. But a little consideration shows that this was entirely needless. If, instead of doing this, the valves had been worked in a different way, a fall of 35 feet would have compressed the air just as well as a fall of 85 feet. The mean pressure due to compression to 6 atmospheres equals 61 feet of water. When the fall was 85 feet the water would give a mean pressure throughout the height of air column of 85 feet, less the loss of effect from fluid friction, etc. Hence if the efficiency was 75 per cent., the flow of the water would be adequate to compress all the air above the level. The gross energy developed would evidently be represented by 85 feet × height of air column. Now with a fall or head of 35 feet, suppose that after the chamber was emptied of water through the second valve, instead of

then closing it before opening the first valve, the latter had been opened while the second still remained open. Water would then have flowed away through the second valve, and when the column had acquired a certain velocity the valve would be shut, and the compressing stroke would then take place. The energy available for compression would then be represented by length of column of water in pipe x head due to velocity + 35 feet x height of air column, and it is evident that by making the velocity a certain amount—that is, by keeping the second valve open a certain time—the amount of this energy can be made exactly as great (or greater if desired) than the energy that was developed under 85 feet head. In 1891, the author described in a paper in the *Proceedings* of the Institution of Civil Engineers an engine of considerable size for pumping water on the principle of the hydraulic ram, and then mentioned that he had also made experiments in compressing the air in the same manner. One of these engines has since been erected on the River Kent, in Westmoreland from the author's design. This also consists of a pipe from the source of supply, and a chamber in which the air is compressed by the momentum of the water. But in this engine the method of using the water is that which the author suggested should have been used at Modane. The water runs freely away through the valve for a certain time in order that it may acquire a certain velocity and momentum. The valve is then closed and the energy available for compression is exactly as the author already formulated it. Consequently, such an engine may be used on a fall, however small. In this engine there is only one valve in place of Sommeiller's two. The air valve admits a fresh supply of air into the receiver after the compression is accomplished, and also allows of the escape of some of this air while the main valve is closing, so that part of the water which flows in the main pipe during this time can rise freely in the chamber instead of having to find an exit through the narrowing orifice of the main valve. The valve is closed by the water when it reaches a float attached to a lever in connection with the valve. There being but one water valve, there is but little gear required to operate it, but it is necessary that the valve should open and shut at certain definite intervals of time. The author has used several different forms of gear for this purpose. In the earlier engines it was a cam, in the Kent engine it is a crank motion. In all cases the power to operate the gear is taken from the air vessel. In the Kent engine water is used. In other cases an air motor has been used. In the Sommeiler engine it was only possible to make three strokes per minute, probably on account of the imperfection of the way of operating the large valves, and because apparently certain pauses were necessary between each stroke. In this engine, there are, of course, no pauses, and from fifteen to twenty strokes are made per minute, so that an engine of given size will develop a much greater power. The height of the chamber is also reduced one-half by making its diameter half as large again as that of the main pipe. The working of this engine has fully justified the author's expectations. In the compression of the air practically all the heat developed is absorbed as it is developed—as, indeed, it seems obviously must be the case, for the compression is effected in a chamber which is cooled at every stroke by being filled with a mass of cold water, and therefore, in the midst of a mass of cold wet cast iron on sides and top and of cold water below. The ribs of the valve plate further add to the mass of cold iron and to its surface. A registering thermometer was suspended in the air vessel, and after several hours running the highest temperature shown was about 2 deg. above that of the water. The engine runs with perfect smoothness and regularity without any noise (even as much as that of the ordinary pumps) or concussions of any kind. It is essentially an hydraulic ram, and the popular idea of a ram appears to be that the essence of its action consists in a blow. This idea has, of course, no scientific foundation, but practice is perhaps more convincing than theory, and the fact is very practically demonstrated here. It will be obvious that air is here compressed without any intermediate transformation of power, and therefore the three sources of loss of power referred to in the beginning of this paper are reduced to one. The other unavoidable sources of loss are also small. The fluid friction is merely that in a plain pipe of no considerable length, and the moving parts are very few and such movement is slow. The efficiency, therefore, is, as a necessary consequence, very high, amounting to 80 per cent. That is, the work done measured in isothermic compression of air is 80 per cent. of the gross power of the water.

TO BE CONTINUED.

ALPHABETICAL LIST OF ALL INVENTIONS.

FOR WHICH PATENTS HAVE BEEN GRANTED ON PNEUMATIC APPLIANCES, PREPARED ESPECIALLY FROM OFFICIAL RECORDS FOR "COMPRESSED AIR,"

BY GRAFTON L. McGILL.

APPLIANCE.	NAME OF INVENTOR.	DATE OF ISSUE.	NO.
Air and Gas Engine	A. H. De Villeneuve.	March 19, 1872	124,671
" "	D. Dick	April 9, 1867	63,619
" "	J. F. Haskins	July 16, 1872	129,337
" "	O. Trossin	July 22, 1873	141,189
" "	P. Shearer	Sept. 3, 1861	33,215
Air and Liquid Cooler	D. E. Somes	March 29, 1870	101,392
Air and Steam Engine	F. B. Blanchard	July 10, 1855	13,209
" " "	O. M. Hillman	Aug. 9, 1864	4,380
Air and Steam Jet Combustion	G. M. Copeland	Feb. 26, 1867	62,397
Air Bath	S. M. Laudis	May 14, 1867	64,677
Air Blast Engine	J. Grimm	Oct. 26, 1869	96,223
Air Blower	L. Chase	Aug. 12, 1873	141,762
"	"	Sept. 30, 1873	143,329
"	J. Griffin	March 1, 1859	23,084
Air Brake	T. Luce	Sept. 10, 1872	131,286
" and Signal	G. Westinghouse	March 5, 1872	124,404
"	L. H. Develley	Nov. 28, 1865	51,158
"	C. Fogelberg	May 28, 1872	127,332
"	T. O. Ward	Jan. 30, 1872	123,312
"	G. Westinghouse	Oct. 28, 1873	144,005
"	"	March 5, 1872	124,405
"	H. L. McAvoy	April 29, 1873	138,339
"	G. Westinghouse	Jan. 23, 1872	123,067
Air Chamber	R. Creuzbaur	June 18, 1861	32,595
Air Compressor	W. Arthur	July 25, 1865	48,886
"	J. B. Mignon	March 19, 1867	63,075
"	B. T. Babbitt	May 17, 1870	103,121
"	"	Nov. 12, 1872	133,004
"	F. S. Dumont	April 27, 1869	89,390
"	G. D. Emerson	Aug. 20, 1872	130,627
"	J. Ericsson	Dec. 30, 1873	146,055
"	R. S. Pardée	Oct. 14, 1873	143,634
"	J. S. Patric	April 18, 1865	47,328
"	"	Oct. 17, 1871	120,094
"	J. B. Waring	July 16, 1872	129,631
Air Condenser	J. Cochrane	July 23, 1872	129,791
"	H. J. Bailey	Jan. 14, 1868	73,283
"	H. Moore	March 3, 1868	75,042
"	J. S. Patric	Oct. 17, 1871	120,095
Air Cooler and Ice Manufacturer	J. Kraffert	Dec. 27, 1870	110,573
"	T. D. Kingan	July 1, 1873	140,375
"	N. S. Shaler	May 30, 1865	47,991
"	E. H. Grant	Feb. 16, 1869	87,041
"	F. Villard	May 29, 1866	55,180
Air Cushion	J. W. Wetmore	Sept. 2, 1873	142,540

ALPHABETICAL LIST OF ALL INVENTIONS.—*Continued.*

APPLIANCE.	NAME OF INVENTOR.	DATE OF ISSUE.	NO.
Air Draft	S. Randall	March 12, 1811	no n'ber
Air Engine	W. Alworth	May 28, 1872	127,137
"	J. B. Atwater	March 13, 1866	53,097
"	D Bickford	June 6, 1865	48,043
"	J. R. Cameron	Nov. 12, 1867	70,800
"	P. Chick	Dec. 18, 1866	60,474
"	W. Deukmann	Dec. 16, 1862	37,155
"	J. Ericsson	Nov. 4, 1851	8,481
"	"	July 31, 1855	13,348
"	"	April 15, 1856	14,690
"	"	Dec. 14, 1858	22,287
"	"	Oct. 9, 1860	30,306
"	E. Langen	Aug. 13, 1867	67,659
"	F. J. Laubereau	April 10, 1849	6,301
"	J. J. Lenoir	March 19, 1861	31,722
"	R. Lord	Sept. 17, 1861	33,308
"	A. S. Lyman	Feb. 28, 1854	10,576
"	T. McDonough	Sept. 23, 1856	15,771
"	H. Messer	Jan. 6, 1863	37,299
"	D. Myers	Nov. 15, 1870	109,338
"	J. R. Napier	Sept. 19, 1854	11,696
"	H. Norman	Feb. 25, 1873	136,259
"	H. M. Paine	Nov. 30, 1858	22,219
"	J. R. Peters	Nov. 18, 1862	36,964
"	B. F. Rice	April 5, 1859	23,495
"	A. K. Rider	Jan. 17, 1871	111,088
"	"	Oct. 24, 1871	120,325
"	P. Shaw	May 2, 1854	10,868
"	O. M. Hillman	June 26, 1860	28,910
"	"	June 26, 1860	28,911
"	S. Wilcox	May 3, 1859	23,876
"	"	Nov. 20, 1860	30,700
"	"	Nov. 20, 1860	30,701
"	"	Sept. 19, 1865	50,061
"	A. O. Wilcox	July 19, 1853	9,871
"	J. McLeish	Dec. 10, 1872	133,713
"	J. A. Woodbury	May 17, 1853	9,739
"	"	Oct. 4, 1853	10,081
"	P. A. Ensign	Oct. 2, 1866	58,397
Air-Heating	L. C. St John	Oct. 7, 1851	8,413
Air-Supply and Boilers	G. E. Hibbard	Dec. 16, 1873	145,568
Apparatus for Cooling Air	T. D. Kingan	Dec. 16, 1873	145,659
" " "	D. E. Somes	Nov. 12, 1867	70,909
Apparatus for Navigating the Air	C. McDermott	Nov. 12, 1872	133,046
" " "	W. F. Quinby	Nov. 26, 1861	33,797
" Purifying "	A. S. Lyman	Jan. 19, 1864	41,309
" Removing Dust from the Air	J. D. Whelpley	March 6, 1866	53,068
" Supplying Continuous Flow of Air	B. Rouquarol	March 20, 1866	53,385
" Transmitting Air Power	H. Calf	Aug. 24, 1869	93,964
" " "	"	Jan. 18, 1870	98,846

PATENTS GRANTED FEBRUARY, 1898.

Specially prepared for COMPRESSED AIR from the Patent Office files by Grafton L. McGill, Washington, D. C.

599,348—Air-Brake. H. F. Noyes, Elgin, Ill. Assignor to the Westinghouse Air-Brake Co., Pittsburgh, Pa.

This invention embodies a valve-construction to be used in conjunction with what is known as the "Westinghouse" system of air-brakes. The invention relates particularly to the action of the triple-valve, the rapid application of which is very necessary in sudden stopping of the train, the necessity becoming more urgent as the length of the train increases. In the systems heretofore employed the air at the last triple must be set in motion and travel the whole length of the train-pipe to the engineer's valve. By this invention a preliminary admission of pressure is transmitted to each brake-cylinder from the train pipe, such admission causing a local reduction of pressure in the vicinity of each triple sufficient to operate it, to admit pressure from an auxiliary reservoir to the brake-cylinder, so that starting from the engine each triple acts on the next, and so on. As soon as one triple has admitted enough pressure from the train-pipe to the brake-cylinder to reduce the pressure of the former a certain amount, further admission therefrom is cut off, and admission from the auxiliary reservoir takes place until the graduating-valve cuts off, or the pressures equalize.

598,149—Air-Compressor. Joseph H. Hoadley, New York, N. Y. Assignor to Compressed Air Power Co., New York, N. Y.

A compound air compressor consists of high and low pressure cylinders, the latter being large enough to supply more compressed air than is required by the high pressure cylinder. A passage leads from the compound air-compressor between the high and low pressure cylinders and communicates with an apparatus driven by compressed air. A second passage leads from the low pressure cylinder to an air-heater, while an air motor communicating with said heater, and driven by the heated air therefrom, drives the air compressor.

598,283—Governor-Valve for Air-Compressor. N. A. Christensen, Milwaukee, Wis.

The suction valve of an air pump is provided with means for positively moving the same from its movable seat. Passages admit reservoir-pressure to the seat, and valve moving means to actuate the valve in opposite directions; while a spring is interposed between the valve-seat and valve-moving mechanism in a manner to resist such pressure and bring said seat and valve back again to their normal positions when the excess pressure is removed.

598,102—Pneumatic Spring. W. Kowaleff, Oofa, Russia.

An air-cylinder carrying a suitable piston has its rod projecting on both sides thereof. The piston-head is provided with a guide for one end of the rod, while the other end is mounted in a spring resting in a seat on the journal-box. The cylinder is supplied with air and provided with a valve to prevent escape of air therefrom when supply is cut off.

598,766—Compressed-Air Disc-Brake. M. E. Campany, Hamilton, Mich.

The brake-shoes of the ordinary construction employed on railroad car wheels are supported by rods or links depending from the car truck. Brake-bars are pivoted to the shoes and extend toward each other and are also supported by the car truck by chains attached to their inner ends. At the inner end of each brake-bar is secured a diaphram, the two being intimately secured to each other at their outer edges. The outer and inner sides of each diaphram are provided with a plate to reinforce the connection with the brake-bars. The diaphrams are connected by a flexible tube in the ordinary manner to the train-pipe.

599,080 Air Cleaning and Cooling Device. Joseph McCreery, Toledo, Ohio.

An air cleansing case is provided with two alternating series of solid shelves placed at an incline across the case. The shelves of each series are secured at one end to one side of the case, the other end being free. Air and water induct pipes are introduced into the case above the shelves, while their respective educts are located below the shelves.

599,055—Pneumatic Tobacco-Leaf Conveyor. S. C. Davidson, Belfast, Ireland.

A blast pipe is provided with an enlargement at its upper side where the material is fed to said pipe through a hopper. A flap-door or valve is located between the hopper and the blast pipe and is normally open toward the latter, so that when the charge of material is fed from the hopper through the door, into the pipe, temporary back-pressure of said air-blast-pipe is brought to bear against and automatically close the door until said back-pressure ceases.

598,982—Pneumatic Spring. E. L. Egger, Centralia, Ill.

This invention consists of an air-chamber having a flexible diaphram and the end of a movable stem extending through an opening in said diaphram. The base is provided with a lining and a cap, the flexible diaphram being secured between the edges of said base and said cap. The movable stem is provided with a nut and washer on the inner side of said diaphram.

599,279—Pneumatic Stacker. G. W. Wood, Woodburn, Ill.

The frame is attached to the machine and carries a ring, a track being secured to said frame and ring. An inner cylinder-section is located within said frame and ring, while an outer cylinder-section is adapted to fit over said former section. Rollers carried on the lower end of the outer section are adapted to bear against the track while roller-wheels in the stationary ring are adapted to bear against a second track also secured to the outer section Thus the outer section slides on the inner section.

599,421—Street Car Air-Brake. Charles A. Gray, Kansas City, Kan.

This device consists of a compressed air apparatus, comprising a storage tank, an air-pump, and a conductor for compressed air connected with the pump and tank. The brake cylinder is provided with heads and a piston and its rod, while a valve box having separate inclined air-passages is located upon the cylinder. Each of these passages extends from the brake cylinder near the head thereof within the central portion of the valve box. The valve rod is provided with separate valves, each normally in position between one of the passages for the air and the cylinder-head. The conductor that connects with the air tank also communicates with the valve box at a point between the separate valves. The valve carrying rod is operated by the motorman.

599,509—Drier. A. S. Livengood, Everson, Pa.

A series of inclined racks or shelves are arranged one above the other, each shelf being formed of a number of lines of pipes arranged around three sides of a square, the fourth side being left open and the inner pipes concentric with the outer pipes. The corresponding pipes of each rack are in the same vertical plane forming the opening in one side. Headers run perpendicularly and connect the ends of corresponding pipes in the several racks or shelves, a separate pipe connecting said headers to a source of supply.

99,647—Fruit Drier. Steevens & Steevens, Salem, Oregon.

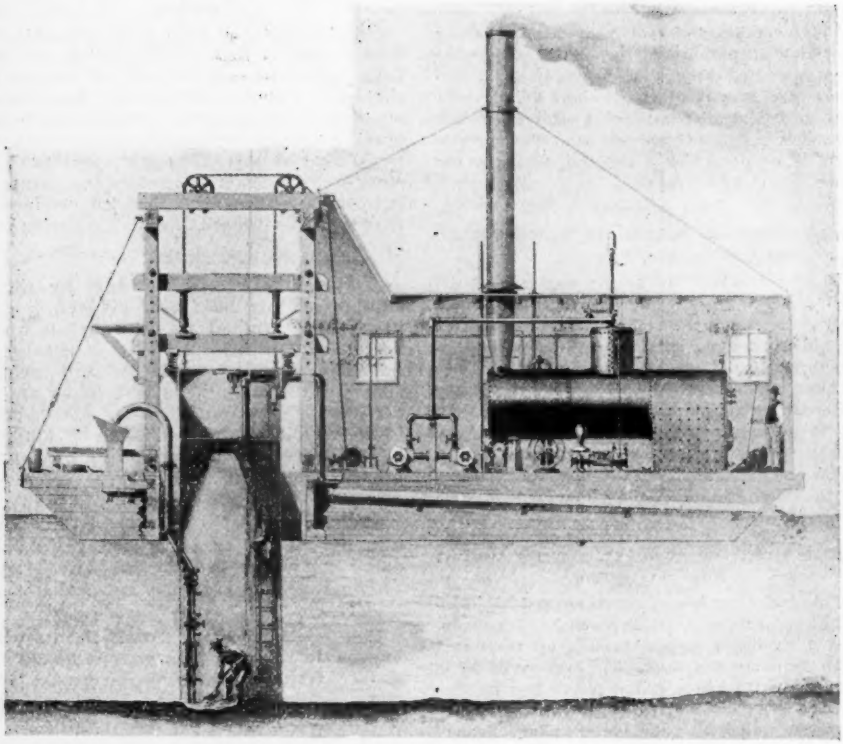
A vertical series of trays is so arranged as to have a space in front communicating with the spaces formed between the trays and common to the series. A vertical wall separates the rear ends of the trays from an air shaft and is provided with openings opposite the spaces formed between the trays, dampers controlling said openings. The air or drying medium is admitted into the space in front of the trays and is then deflected toward the trays by an inclined outer wall enclosing said space.

A system of sterilizing milk by using compressed air has been evolved. Too much heat applied to milk in an open vessel scorches it. As it is necessary to have 240 degrees of heat to kill certain spores in the milk it is put under an air pressure of 30 pounds, This allows heat to the extent of 270° to 280° to be applied and still keep down the boiling point and prevent scorching.

Mr. George Cohen has resigned his position as general manager of the Consolidated Pneumatic Tool Co., and Mr. George T. Hartford of Boston has succeeded him.

Chas. G. Eckstein & Co. of Berlin, with branch in New York, has removed to Kaiser Wilhelmstrasse, 8 Berlin C., Germany, where they occupy a large store in the machinery centre.

With the present issue we begin our third volume of "COMPRESSED AIR." During the past two years we have endeavored to improve our paper month by month, and beg to assure our readers that it is our constant aim to make "COMPRESSED AIR" an absolute authority on all matters pertainfng to this science. With this number we begin the publication of a list of patents, to which reference was made last month, and which we think will be a valuable addition to compressed air literature We would also inform our readers that we have had a number of copies of Volume II. bound, and will have them ready for sale about the beginning of April. The price of these bound volumes is $2.00 each, and as we have but a limited number, we would advise those who wish to secure a copy to send in their order immediately, otherwise we will be unable to fill it, and we feel sure that these bound volumes will prove a valuable addition to any scientific library.



SUBMARINE GOLD MINING MACHINE.

Compressed Air Dredger for Gold Mining.

In general, as shown above, these machines are iron caissons, which can be raised or lowered through the center of a boat or barge, the water being expelled by the proper pressure of compressed air. The bottom is thus exposed to the direct manipulation of the miner who is within the caisson, and he picks or otherwise loosens up the earth or gravel on the bottom and sends it to the surface through the small internal discharge pipe, either by direct air or water pressure as he desires.

This apparatus consists of an air compressor and appurtenances for operating it. The equipment being very complete with telephones, traps, pipes, ejectors, etc.

This machine does not interfere with the dredgers, the idea being to clean up the bedrock in the cracks and crevices wherein lie the heavy gold which no dredger of any kind has ever been able to lift. Dredgers working on rivers have to stop when they have cleared off the upper portion of the bed rock. They cannot go into the holes or crevices.

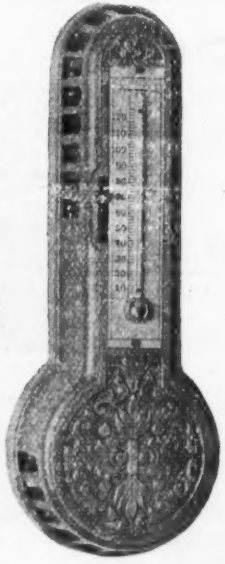
No bad effects upon the operator are produced as the pressure is moderate and invigorates rather than depresses the worker.

Men work in caissons at 25 to 30 pounds pressure per square inch, which corresponds to 60 and 70 of water pressure.

This machine is intended for such rivers as the Yukon and is manufactured by Rix & Donahoo, San Francisco.

THE DAVIS & ROESCH,

THERMOSTAT.



Temperature Controlling SYSTEM.

Do you desire an even temperature in your house and office?

Do you consider an even temperature conducive to health and comfort?

Do you find an even temperature difficult to maintain?

Do you think your fuel bills are too high?

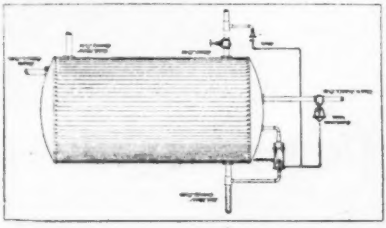
Do you consider economy of health and wealth wise?

We assume there can be but one intelligent answer to these queries, and would suggest an investigation of our system as a means of attaining these most desirable ends.

Hot Water Regulator.

Attach it to your hot water tank and it will save *you* fuel and your *engineer* trouble.

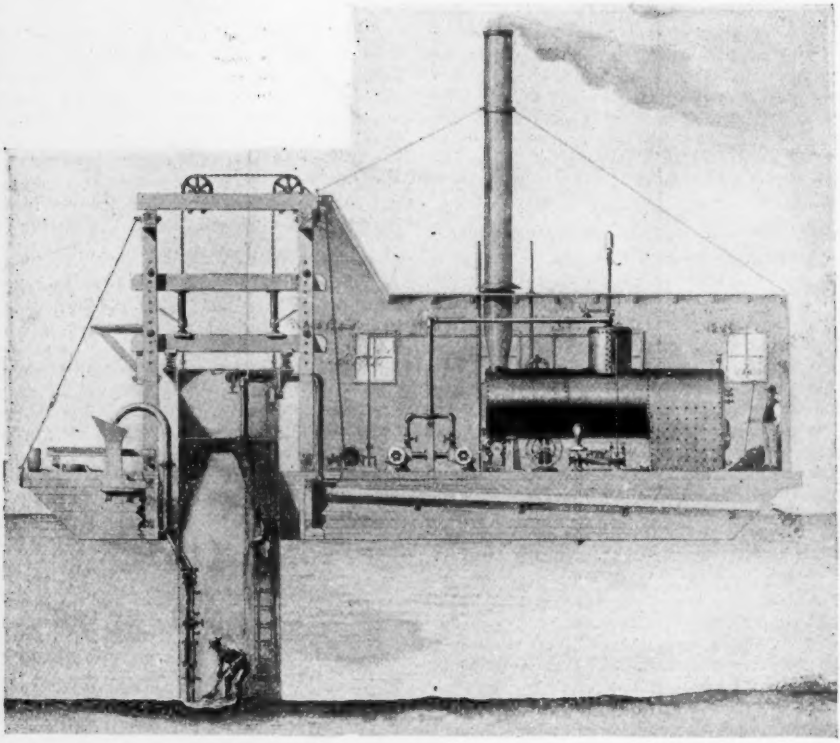
It assures a regular and even supply of hot water, and by preventing over-heating avoids all possibility of the straining of water pipes or faucets, and the cracking of basins or tubs.



THE DAVIS & ROESCH TEMPERATURE CONTROLLING CO.,

TREASURER'S OFFICE.
Havemeyer Bldg, 26 Cortlandt St., New York.

FACTORY.
Bridgeport, Conn.



SUBMARINE GOLD MINING MACHINE.

Compressed Air Dredger for Gold Mining.

In general, as shown above, these machines are iron caissons, which can be raised or lowered through the center of a boat or barge, the water being expelled by the proper pressure of compressed air. The bottom is thus exposed to the direct manipulation of the miner who is within the caisson, and he picks or otherwise loosens up the earth or gravel on the bottom and sends it to the surface through the small internal discharge pipe, either by direct air or water pressure as he desires.

This apparatus consists of an air compressor and appurtenances for operating it. The equipment being very complete with telephones, traps, pipes, ejectors, etc.

This machine does not interfere with the dredgers, the idea being to clean up the bedrock in the cracks and crevices wherein lie the heavy gold which no dredger of any kind has ever been able to lift. Dredgers working on rivers have to stop when they have cleared off the upper portion of the bed rock. They cannot go into the holes or crevices.

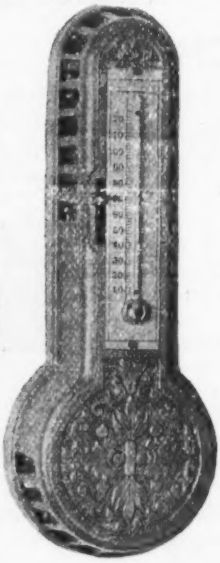
No bad effects upon the operator are produced as the pressure is moderate and invigorates rather than depresses the worker.

Men work in caissons at 25 to 30 pounds pressure per square inch, which corresponds to 60 and 70 of water pressure.

This machine is intended for such rivers as the Yukon and is manufactured by Rix & Donahoo, San Francisco.

THE DAVIS & ROESCH,

THERMOSTAT.



Temperature Controlling SYSTEM.

Do you desire an even temperature in your house and office?

Do you consider an even temperature conducive to health and comfort?

Do you find an even temperature difficult to maintain?

Do you think your fuel bills are too high?

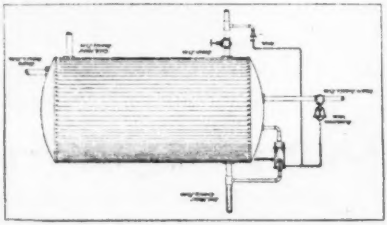
Do you consider economy of health and wealth wise?

We assume there can be but one intelligent answer to these queries, and would suggest an investigation of our system as a means of attaining these most desirable ends.

Hot Water Regulator.

Attach it to your hot water tank and it will save *you* fuel and your *engineer* trouble.

It assures a regular and even supply of hot water, and by preventing over-heating avoids all possibility of the straining of water pipes or faucets, and the cracking of basins or tubs.



THE DAVIS & ROESCH TEMPERATURE CONTROLLING CO.,

TREASURER'S OFFICE.
Havemeyer Bldg, 26 Cortlandt St., New York.

FACTORY.
Bridgeport, Conn.

Lubrication .. Oil Pump.

Used for lubricating Air and Steam Cylinders, and Main Bearings of Shafts on large Hoisting Engines, prevents them from getting hot. When engine stops, cup stops feeding.

McCanna Bros.
57 Wells St.,
Chicago, Ill.

TECHNICAL EDUCATION 50 CENTS A WEEK

$2 in advance and the balance at the rate of $2 a month, pays for a thorough course of instruction in

MECHANICS

Mechanical Drawing; Steam Engineering; Electrical and Civil Engineering; Refrigeration; Chemistry; Mining; Architectural Drawing; Surveying and Mapping; Sanitary Plumbing; Architecture; Sheet Metal Pattern Drafting; Prospecting; Bookkeeping; Shorthand; English Branches.

All who study

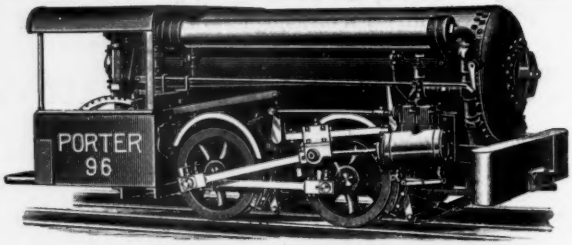
GUARANTEED SUCCESS.

TAUGHT BY MAIL

We have helped thousands to better positions.

Circular Free; State subject you wish to study.

The International Correspondence Schools,
BOX 1182. SCRANTON, PA.



Compressed Air Mine Haulage.

Safe from fire, handier, more reliable and more economical in installation and operation than other systems; adopted by representative anthracite and bituminous collieries after exhaustive examination. On *bona fide* request of mine owner or superintendents, or other prospective buyer, we will mail free our 8th Edition, 216 page catalogue, of steam, electric and pneumatic locomotives. To accommodate correspondents not in the market for locomotives, a copy will be mailed on receipt of 50 cents in stamps.

Address mentioning "COMPRESSED AIR."

H. K. PORTER & CO., 540 Wood St., Pittsburgh, Pa.

THE CONSOLIDATED PNEUMATIC TOOL COMPANY,

Office, No. 1404 Bowling Green Building, New York.

ANNOUNCES—

That it has purchased all of the patent rights, drawings, special tools and stock on hand of the former manufacturers of the "Wolstencroft" Pneumatic Tool;

That it has purchased all of the patent rights, drawings, special tools and stock on hand of the former manufacturers of the "Keller" Pneumatic Tool;

That it has developed and perfected a new Pneumatic Tool, known as the "Consolidated," which combines all that is best in its numerous patents, and is the simplest, best cutting, least vibrating and most economical Tool ever produced;

That it is prepared to supply either the "Wolstencroft" or "Keller," or new " onsolidated types of Pneumatic Tools" in any size, suitable for cutting or carving granite, marble, brown-stone, blue-stone, onyx, etc., at the uniform and absolute price of SIXTY DOLLARS ($60) PER TOOL.

That it will send any or all patterns and sizes of Tools upon TEN DAYS' TRIAL, subject to acceptance or return at the expiration of that period, thus permitting the tools to stand entirely upon their merits and be their own arguments.

That it considers the constant threats of litigation, misrepresentations and sliding scale of prices, which have identified the pneumatic tool trade heretofore, as decidedly injurious to the best interests of Tool users and manufacturers alike; but this Company is prepared to firmly maintain the validity of its patents against whomsoever may assail them. And as a guarantee of its ability to jealously guard its own and its customer's rights, this ¡ompany calls attention to the business reputation and integrity of ts Board of Directors, which governs its affairs and controls its policy.

This Company inaugurates a new era in the Pneumatic Tool trade, an era of sound business methods, of moderate and invariable price to all alike. Possessed of wide experience in its management and sales representatives, it is prepared to install Air Compressors, Air receivers and Pneumatic Tool Equipment, complete, guaranteed to develop the highest efficiency and economy.

IF YOU HAVE AN AIR COMPRESSOR, send for our Tools upon trial.

IF YOU HAVE NO AIR COMPRESSOR, write us for proposal upon a plant, complete.

The Consolidated Pneumatic Tool Co.,

No. 1404 BOWLING GREEN BUILDING, NEW YORK.

NEW YORK OFFICE:

122 LIBERTY STREET, ROOMS. 1005-1006, NEW YORK.

MANUFACTURERS OF

PNEUMATIC HAMMERS
PISTON AIR DRILLS
PNEUMATIC RIVETERS
CASTING CLEANERS
AIR HOISTS

All Machines guaranteed against repairs for one year.

Sent on 10 days trial subject to approval.

OVER 2,000 IN USE IN THE UNITED STATES.
OVER 800 IN EUROPE.

REFERENCES FURNISHED UPON REQUEST.

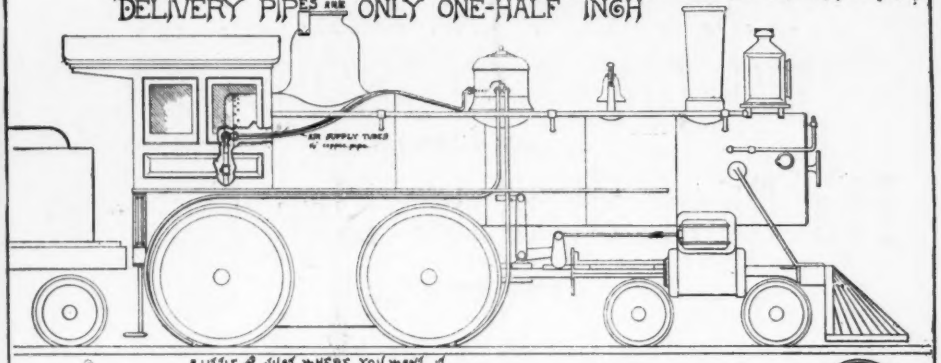
TRIAL ORDERS SOLICITED.

Chicago Pneumatic Tool Co.,

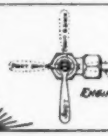
635 MONADNOCK BLOCK - CHICAGO, ILL.

HOUSTON'S PNEUMATIC TRACK SANDER.

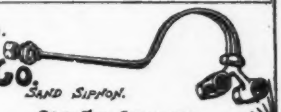
SIPHONS & EJECTS SAND FROM BOX TO RAIL.
APPLIES SAND TO BOTH FRONT & BACK DRIVERS FROM ONE BOX.
NO DELAY TO ENGINE FOR IT CAN BE APPLIED IN SIX HOURS.
DELIVERY PIPES ARE ONLY ONE-HALF INCH



A LITTLE OF JUST WHERE YOU WANT IT
AND NO POWER LOST IN PULLING TRAIN OVER SUPERFLUOUS SAND.


ENGINEERS VALVE.

WESTERN RAILWAY EQUIPMENT CO.
ST. LOUIS MO.


SAND SIPHON.

SEND FOR CIRCULARS

THE ENGINEERING MAGAZINE

AN INDUSTRIAL REVIEW

The Engineering Magazine has been aptly described as "*The Century* of the industrial world and the *Review of Reviews* to engineering literature—the two in one." Its leading articles treat the subjects uppermost in importance in industrial affairs. Its contributors include the foremost men of our times. It gives each month an exhaustive Review and Index to the world-wide range of technical literature—American, English, French, and German. It is read in every nook and corner of the civilized world. It is founded upon the idea of meeting the requirements of the busy and brainy men who manage, think, and plan for the engineering, architectural, electrical, railroad, mining, and mechanical industries. It has a larger bona-fide circulation among such men than has ever been attained by an engineering journal in all the history of industrial literature. It is priceless to the active man who needs to keep in touch with current developments. Its every page carries a living interest for intelligent readers who are in any way concerned with modern industrial enterprises. Its subscribers are its warmest advocates and the Magazine itself is its best solicitor. *Sample copy free.*

30 Cents a Number; $3.00 a Year.

THE ENGINEERING MAGAZINE,
120-122 Liberty St., New-York, U.S.A.

Compressed Air.

Practical information upon Air-Compression and the Transmission and Application of Compressed Air.

By FRANK RICHARDS. 12mo, cloth, $1.50

John Wiley & Sons, New York.

READ "ELECTRICITY,"

The Only Independent Electrical Journal
PUBLISHED IN THE UNITED STATES.
All the Electrical and Financial News.
Latest Technical Articles by Home and Foreign Writers.
THE BEST ADVERTISING MEDIUM.
Published Weekly. Subscription $2.50 per year.
Address: **ELECTRICITY NEWSPAPER CO.,**
136 Liberty St., New York.

Patents, Trade Marks, Designs.

Searches as to Novelty; Reports on Infringements; Patent Matters Exclusively; 15 years Experience. Refers to Publishers this Magazine. FRANKLAND JANNUS, Attorney-at-Law, Havemeyer Building, 26 Cortlandt St., New York City.—Office in Washington, Atlantic Building.
Always have Title Examined before Investing in Patent Property.

Do You Roast Your Ores?

. . . . YOU CAN SAVE . . . .

FUEL, COST OF REPAIRS AND LABOR,

BY USING

The Ropp Straight Line Furnace,

FOR SALE BY

PARKE & LACY CO.,

21 & 23 Fremont Street, San Francisco, Cal.

SOLE LICENSEES. CATALOGUE UPON APPLICATION.

THE "NASON" AIR-HOIST

. . CYLINDERS . .

For use in conjunction with Compressed Air.

Made in sizes of from 2 in. to 8 in. inside diameter, with lift of hoist from two to ten feet.

CONTRACTORS FOR

The Installation of Pneumatic Hoisting Apparatus.

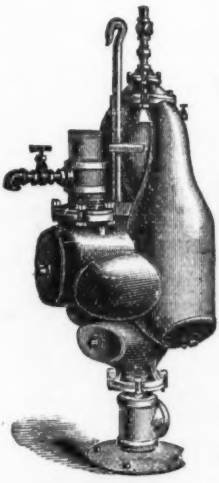
. . . SAFE, SIMPLE AND RELIABLE . . .

Correspondence Solicited.

NASON MANUFACTURING CO.,

71 BEEKMAN STREET, NEW YORK.

THE PULSOMETER STEAM PUMP



"The Contractor's Friend."

OFTEN IMITATED—NEVER EQUALED.
OVER 20,000 IN USE.

Recent Important Improvements.

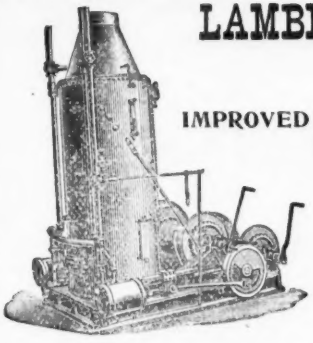
The Handiest, Simplest and Most Efficient Steam Pump for General Low Service Mining, Quarrying, Railroad, Irrigating, Drainage, Coal-washing, Tank-filling, Paper Mill, Sewer and Bridge Contractors' Purposes, etc., etc.

Muddy or gritty liquids handled without injury to the Pump.

PULSOMETER STEAM PUMP CO.

Catalogue on Application. **Correspondence Solicited.**

135 GREENWICH STREET, NEW YORK.



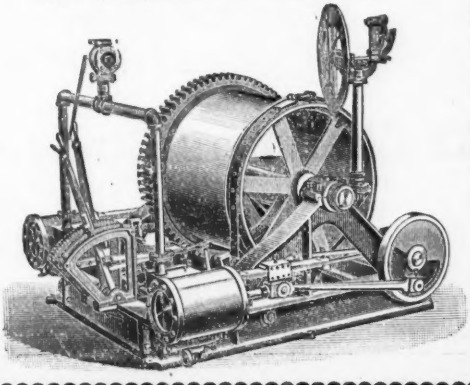
LAMBERT HOISTING ENGINE CO.,

Successors to
W. A. CROOK & BRO.'S,
Manufacturers of

IMPROVED **Hoisting Engines**

FOR PILE DRIVING, RAILROADS, BRIDGES BUILDING, MINES, QUARRIES, COAL HOISTING AND BUILDING PURPOSES.

BUILT ON THE DUPLICATE PART SYSTEM.



OVER 350 SIZES AND STYLES.

Log Hauling by Steam and Suspension Cableways.

BOSTON OFFICE:
117 Main St., Cambridgeport.

MAIN OFFICE AND FACTORY:
117-123 Poinier St. Newark, N.J.

SALESROOM:
143 Liberty Street, New York.

—ON ADMIRALTY AND WAR OFFICE LISTS.—

THE MANNESMANN TUBE Co LTD

LANDORE R.S.O. SOUTH WALES.

D. B. McILWAINE,

SOLE AGENT FOR AMERICA,

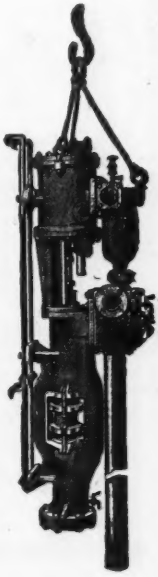
NEW YORK OFFICE:

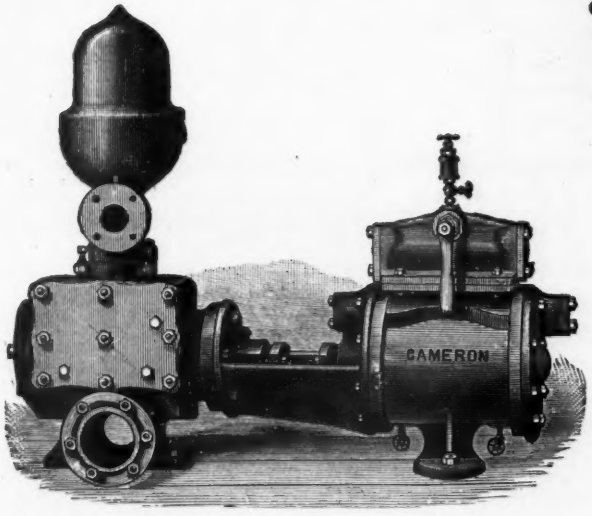
122 Chambers Street, New York.

CAMERON STEAM PUMPS.

Simple,
Compact,
Durable,
Efficient.

NO OUTSIDE VALVE GEAR.





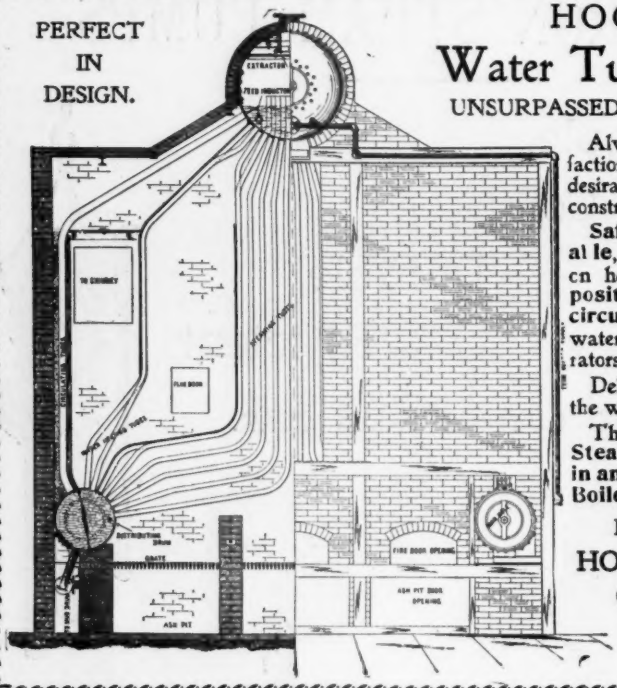
ADAPTED TO EVERY POSSIBLE DUTY.

MANUFACTURED BY

THE A. S. CAMERON STEAM PUMP WORKS,

Foot East 23d Street, New York.

PERFECT
IN
DESIGN.



HOGAN
Water Tube Boilers,
UNSURPASSED IN ECONOMY.

Always give entire satisfaction. Combines every desirable feature in boiler construction and design.

Safe, Efficient, Durable, Free from Scale on heating surface. Has **positive and continuous circulation.** Need no feed water heaters or steam separators.

Delivers all steam above the water line.

The Water Line is Steadier than can be found **in any other Water Tube Boiler.**

Manufactured by
HOGAN BOILER COMPANY,
Middletown,
N. Y.

TO those using compressed air in their works, it will probably be a matter of interest, to know, that we are now selling for **($50) Fifty Dollars Net a Complete Whitewashing and Painting Machine,** for using one nozzle, of the same capacity, as those used in spraying **"Red Lead Paint"** on the Iron work of the New U. S. Appraiser's Stores in this City. As an item of information we will say, the entire expense for doing this work was less than would have been the cost of Brushes to do this same work! and the work is better done than could have been done by hand—for further information write to

TURNER MACHINE CO.,
35 W. 14th treet, New York.

☞ STEAM AND AIR DRILL HOSE A SPECIALTY.

THE MANHATTAN RUBBER MF'G CO.

CABLE ADDRESS "MIALOGIA"
TELEPHONE, 2965 CORTLANDT

Steam Packing,
Pump Valves,
Air Compressor Valves,
Rubber Belts,
Car Springs,
Gaskets,
Suction Hose,
Emery Wheels,

THE MANHATTAN RUBBER MFG. CO
64 CORTLANDT ST. N.Y.

FRANK CAZENOVE JONES,
PRES'T AND GEN'L M'G'R.

ALL KINDS OF MECHANICAL RUBBER GOODS.

Factories: Passaic, N. J. (on D. L. & W. R. R.)

General Office and Salesroom: 64 CORTLANDT ST., NEW YORK

SEND FOR ILLUSTRATED CATALOGUE.

ELECTRIC BLASTING APPARATUS.

Adapted for All Kinds of Explosives used in Blasting.

VICTOR ELECTRIC PLATINUM FUSES.

Blasting Batteries

Leading and Connecting Wires.

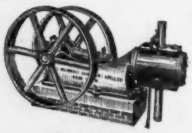
Caps,
Fuse,
Etc.

Manufactured Only by

JAMES MACBETH & CO.,

Send for Catalogue.

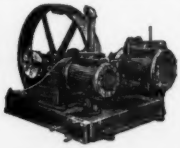
128 Maiden Lane, New York City.



CLASS E.

VARIED SIZES AND TYPES

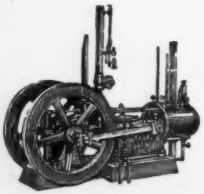
... OF ...



CLASS J.

AIR COMPRESSORS

The types shown here are used in Shops and Mines, or Quarries. Catalogues show a great variety of Machines for Compressing Air. Recent orders from Penn. R. R., Cambria Iron Co., Newport News Shipbuilding Co., Etc., Etc.

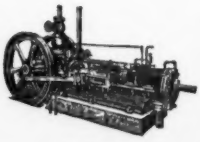


CLASS F.

THE INGERSOLL-SERGEANT DRILL CO.,

Havemeyer Building,

New York.



CLASS A.

CLAYTON

Air Compressors,

For Every Application of Compressed Air Power.

Clayton Air-Lift Pumping System.

CLAYTON AIR COMPRESSOR WORKS,

26 CORTLANDT STREET, - NEW YORK.